ADJUSTMENTS

TEXT

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1. Area Dose Calculator (option)

Special tools:
- calibrated dosemeter, e.g. DALI with measuring cell 77334 or PMX3
- 1mm lead plate

The following parameters are relevant to calculation:
- SID (**S**ource **I**mage **D**istance)
- diaphragm aperture
- added filters
- specific yield of tube
- mAs product
- number of exposures

SID, diaphragm aperture and type of filters are supplied by the diagnostic unit, where they are also adjusted.
In the generator default values are given for the specific yield of a tube and filter correction.
These default values can be found as reference files on floppy disk in order to recreate the original settings if need be.

Reference files:

ref_yiel.tdl	specific yield of tube
ref_2al.tdl	filter 2mm Al
ref_01cu.tdl	filter 1mm Al + 0.1mm Cu
ref_02cu.tdl	filter 1mm Al + 0.2mm Cu

The specific yield curve relates to tungsten anodes and 2.5mm primary filters.
Display on the desk is in [$cGycm^2$].

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1.1. Checking the default adjustment

- Place the lead plate and the measuring cell of the measuring instrument on the table in the central radiation beam. The purpose of the lead plate is to reduce radiation scatter of the table top. Without the plate the test result would be approximately 10% higher using a table top made, for example, of resin bonded paper.

- Perform the following settings:
  - 1m between the focus and the measuring cell (= SMD **S**ource **M**easuring **D**istance)
  - free cassette technique
  - kV-mAs-s technique
  - 10mAs
  - 0.1s
  - collimation 10 x 10cm at the height of the measuring cell
  - no filter

- Determine area dose at the following kV settings and compare it with the respective value displayed on the desk:

	50kV	**80kV (81kV)**	**120kV (117kV)**
displayed product	..... $cGycm^2$	..... $cGycm^2$	..... $cGycm^2$
measured dose	..... cGy	..... cGy	..... cGy
measured area (X x Y)	..... cm^2	..... cm^2	..... cm^2
calculated product	..... $cGycm^2$	..... $cGycm^2$	..... $cGycm^2$
difference	..... %	..... %	..... %

Example:
- displayed area dose product: $8.8cGycm^2$
- measured dose: $890\mu Gy = 0.089cGy$
- calculated area dose product: measured dose $\times$ exposed area = $0.089cGy \times 100cm^2 = 8.9cGycm^2$
- difference in %: $= \frac{8.9-8.8}{8.9} \times 100 = 1.12\%$

- If there are any deviations of over 5% it is recommended that the yield curve be corrected in accordance with the procedure described in 1.2.

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1.2. Correction of the specific yield

Prerequisite:

- Test setup and settings in accordance with section 1.1.:
  - 1m between the focus and the measuring cell (= SMD)
  - free cassette technique
  - kV-mAs-s technique
  - 10mAs
  - 0.1s
  - collimation 10 x 10cm at the height of the measuring cell
  - no filter

Principle:

- For each kV specified a dose measurement is taken under the same conditions. If the distance between the focus and the measuring cell deviates from 1m, all the dose values must be corrected with the square of distance (unit of measurement is [m]). Dividing the dose values by the mAs product set gives the respective current yield.

Procedure:

- Measure dose at each kV checkpoint and use it to calculate specific yield.

  The values determined must be higher at higher kVs settings and produce a characteristic with a slight curve on the graph. If considerable fluctuations are detected, the measurements must be repeated at the points in question.

  Range: 0.00 ... 400.00µGy/mAs

  The values can only be stored in the generator if they are within the range specified and rise uniformly with kV.

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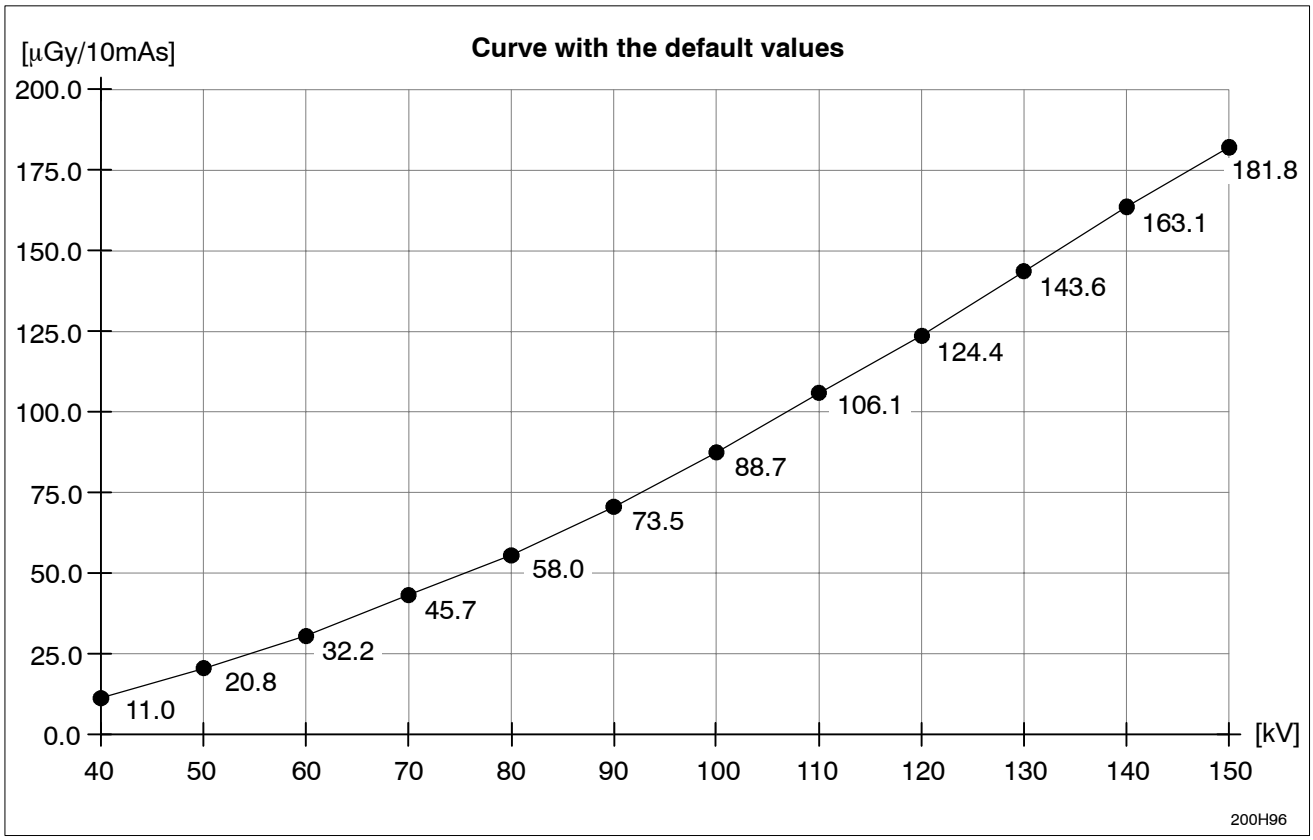
Specific yield

kV checkpoint	40	50	60	70	80	90	100	110	120	130	140	150
default yield [µGy/10mAs]	**11.0**	**20.8**	**32.2**	**45.7**	**58.0**	**73.5**	**88.7**	**106.1**	**124.4**	**143.6**	**163.1**	**181.8**
measured dose [µGy]												
distance^{2}factor	If the distance focus - measuring cell (= SMD) differs from 1m correct the dose with the factor: distance^2 factor = (SMD [m] / 1m)^2 = ... (e.g. = 1.44 for a SMD of 1.2m)											
corrected dose [µGy]												
specific yield [µGy/10mAs]	specific yield = corrected dose/10 mAs											



- Correct the default values of the specific yield for all the kV checkpoints.
  Select menu:
  ADJUST/ AREA EXPOSURE PRODUCT/ **SPECIFIC YIELD OF TUBE 1 ... 3**
  with the factor determined and save with <TRANSMIT>.

- Save the specific yield curve with the SAVE function of XRGSCOPE <F3> key on the backup disk.
  Recommended file name: act_yiel.tdl

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1.3. Correction of the filter values

Prerequisite:

- Test setup and settings in accordance with section 1.1.
  - 1m between the focus and the measuring cell (= SMD)
  - free cassette technique
  - kV-mAs-s technique
  - 10mAs
  - 0.1s
  - collimation 10 x 10cm at the height of the measuring cell
  - no filter

Principle:

- At otherwise identical settings the dose is determined for the kV values specified with and without filter. The ratio of dose values with / without filter produces the respective current correction factor.

Procedure:

- Accept measured dose values (not the corrected ones!) for the respective kV checkpoints from yield measurement or measure them again if any changes have been made to the test-setup or settings.

- Move the filter to be checked into the radiation beam.

- Measure dose at each kV checkpoint and enter it in the respective table.

  Note
  The 40kV range is not used in practice so it does not have to be corrected.
  If in the lower kV range the considerably reduced dose can no longer be measured or read perfectly, at that point a higher mAs product must be selected. Then the repeat measurement must be performed without filter.

- Using the ratio between dose with and without filter, determine the respective correction factor.

  The values determined must be higher at higher kVs settings and produce a characteristic with a slight curve on the graph. If considerable fluctuations are detected, the measurements must be repeated at the points in question.

  Range: 0.000 ... 1.000
  The values can only be stored in the generator if they are within the range specified and rise uniformly with kV.

- Perform the procedure for each selectable filter type.

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Filter correction - 2mm Al

kV-checkpoint [kV]	**50**	**70**	**100**	**150**
default factor	**0.47**	**0.56**	**0.66**	**0.75**
measured dose [µGy] with filter				
measured dose [µGy] without filter				
new factor	**new factor = dose with filter / dose without filter**			

Filter correction - 1mm Al + 0.1mm Cu

kV-checkpoint [kV]	**50**	**70**	**100**	**150**
default factor	**0.25**	**0.37**	**0.50**	**0.65**
measured dose [µGy] with filter				
measured dose [µGy] without filter				
new factor	**new factor = dose with filter / dose without filter**			

Filter correction - 1mm Al + 0.2mm Cu

kV-checkpoint [kV]	**50**	**70**	**100**	**150**
default factor	**0.123**	**0.230**	**0.370**	**0.53**
measured dose [µGy] with filter				
measured dose [µGy] without filter				
new factor	**new factor = dose with filter / dose without filter**			

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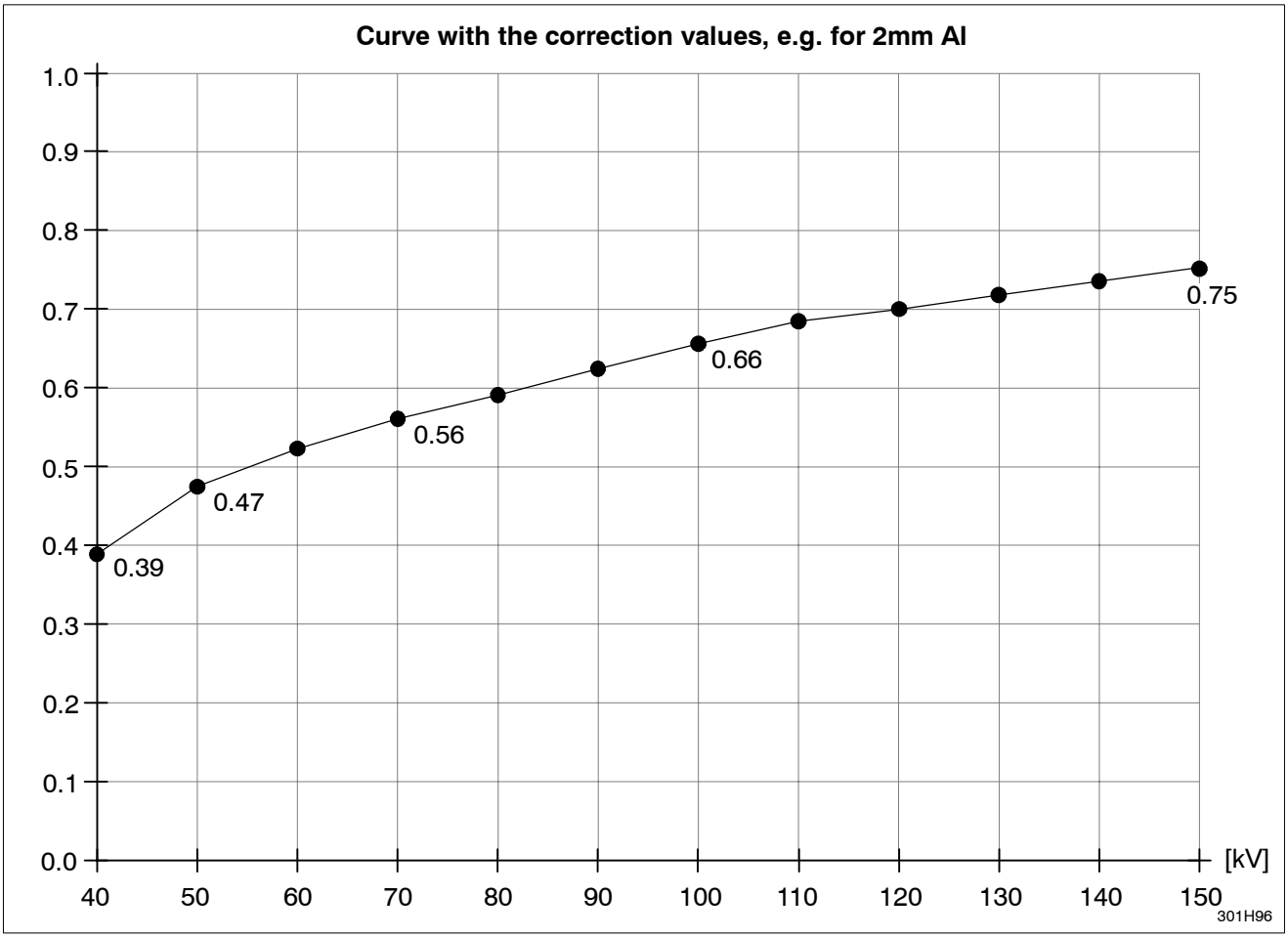

- Read out the default values of the filter tables for each kV checkpoint, correct with the factor determined and write back into the generator with <Transmit>.

  Select menu:
  ADJUST/ AREA EXPOSURE PRODUCT/ ADD FILTER CORRECTION TABLES/ ...

  ... 2mm AL

  ... 1mm AL + 0.1mm CU

  ... 1mm AL + 0.2mm CU

- Save the specific correction tables with the SAVE function of XRGSCOPE <F3> key on the backup disk.

  Recommended file names:

  act_2al.tdl filter 2mm Al

  act_01cu.tdl – filter 1mm Al + 0.1mm Cu

  act_02cu.tdl filter 1mm Al + 0.2mm Cu

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2. Alignment of “Function Unit kV”

2.1. General information

The actual value of the set kV must be attained at least after 2ms. At kV rise phase there must be neither kV break-in nor a kV overshoot.

The Factor Duty Cycle is based on an adapted tube and determines at local mains voltage and mains resistance conditions:

- the kV rise phase

  and

- the kV behavior during the exposure in falling load technique

  as it takes into account the tolerances of the following FRUs (**F**ield **R**eplaceable **U**nits):

1. PCB EZ 130 **

kV_control_3 = 50kW	1 converter	4512 108 0908x
kV_control_4 = 65/80kW	2 converters	4512 108 0910x

2. A complete power converter unit Q **

kV_power PCB(s) Q100	(part of the power converter unit)
IGBT transistors	(part of the power converter unit)

3. Resonance capacitors (part of the power converter unit) **

4. High tension transformer **

An exchange of one of the ** marked parts requires a realignment of the Factor Duty Cycle.

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The Factor Duty Cycle is stored in the memory of PCB CU EZ139. If the CU has to be replaced the CU complete backup can be reloaded (with the actual factor) to the NVRAM memory or the Factor Duty Cycle must be re-aligned. Refer to figure 1:

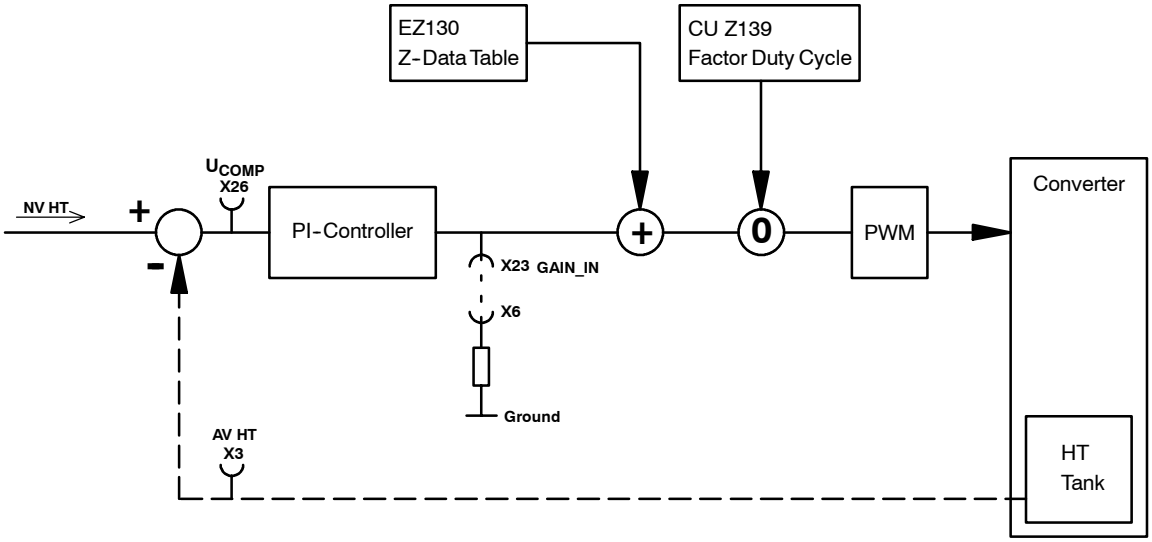

Figure 1 395H00

During alignment this Factor Duty Cycle must be entered via XRGSCOPE. The influence of this factor as a correction value for the Z-Data Table is monitored as the U_{COMP} signal, since the PI-Controller is deactivated by the grounded *GAIN_IN* signal.

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2.2. Connecting and setting the scope

For connections see figure 2:

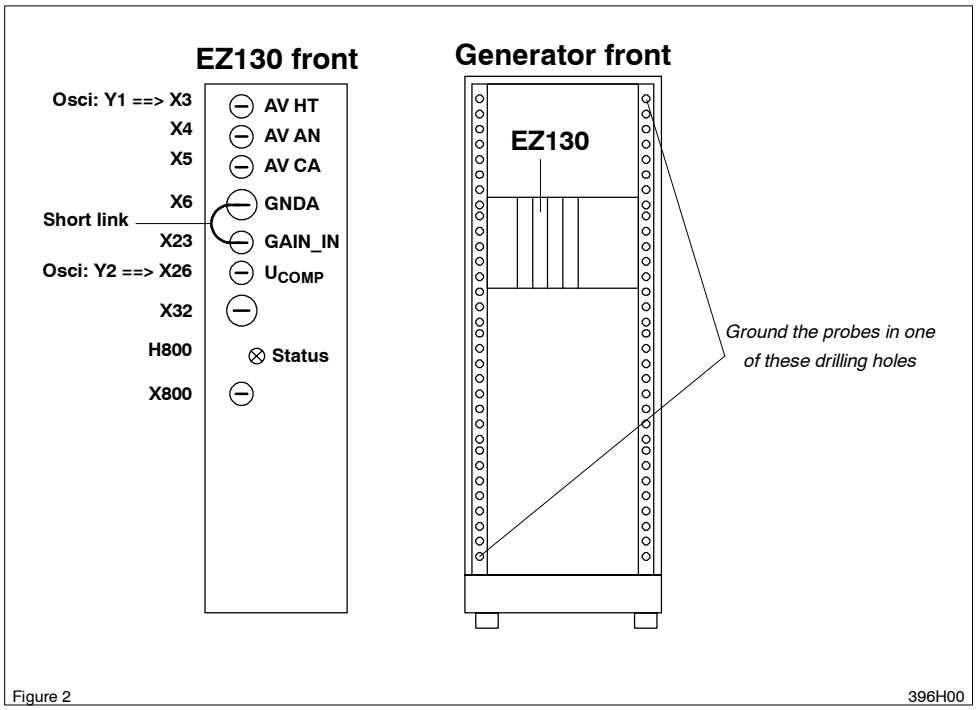

Figure 2 396H00

Channel 1 = EZ130 X3 ---> *AV HT* ---> 20kV/V ---> 1V/div --> Zero-line at bottom of screen
Probe GND = one of the drilling holes at the front cabinet chassis

Channel 2 = EZ130 X26 ---> U_{COMP} ---> 1V/div ---> Zero-line 2 div from bottom of screen
Probe GND = one of the drilling holes at the front cabinet chassis

Trigger = external (preferred) ---> *CTRL_X_C/* ---> backpanel EZX74 / negative slope
or = internal channel 1 ---> *AV HT* ---> EZ130 X3 / positive slope at +3V
Probe GND = one of the drilling holes at the front cabinet chassis

Time base = 5 or 10ms/div ---> trigger delay -1div

Note
A digital scope should not have any other ground connection than the ground of the 3 probes at the drilling holes at the front generator chassis.
A mains driven scope must be isolated from earth potential, otherwise it might display artefacts.

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2.3. Deactivating the kV controller

- Connect EZ130 X23 *GAIN_IN* and X6 *GNDA* with a short link (use a short wire).

Caution!

This alignment requires exposures with high kV.
Be sure the tube has been warmed up before.

2.4. Setting of exposure data

- Perform this adjustment at the tube that has the highest kV limit programmed:
  a) Standard: If the tube limit is 150kV ---> carry out the duty cycle factor adjustment with 141kV.

  b) Special: In case the programmed application limit of the only tube is 125kV ---> use **"Special"** setting for this adjustment.

Note
Any tube arcing during this adjustment requires to execute the tube conditioning next as described in section 2 "INSTALLATION".
Disconnect the short link between X23 and X6.
Start over this adjustment from chapter 2.3 onwards if the tube conditioning was successful.

- Set kV and mA values according to the programmed tube limits:

a) Standard:	141kV	100mA	at	kV_3	(50kW)
		200mA	at	kV_4	(65/80kW)
b) Special:	125kV	100mA	at	kV_3	(50kW)
		200mA	at	kV_4	(65/80kW)

- Set exposure time: 40ms

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2.5. Adjustment of the ”factor for duty cycle”

- Adjust the Factor Duty Cycle via service software XRGSCOPE by measuring U_{COMP} with the scope.
- Connect the service PC and start XRGSCOPE:
  XRGSCOPE
  SELECT UNIT ---> FU-kV ---> ADJUST ---> IGBT Pulse Width Correction ---> Factor Duty Cycle
- Set the starting value Factor Duty Cycle to **1.00**:

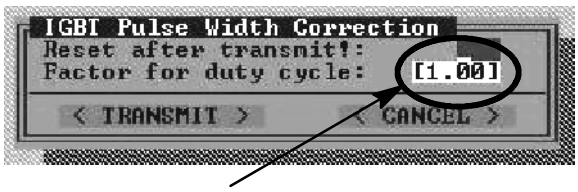
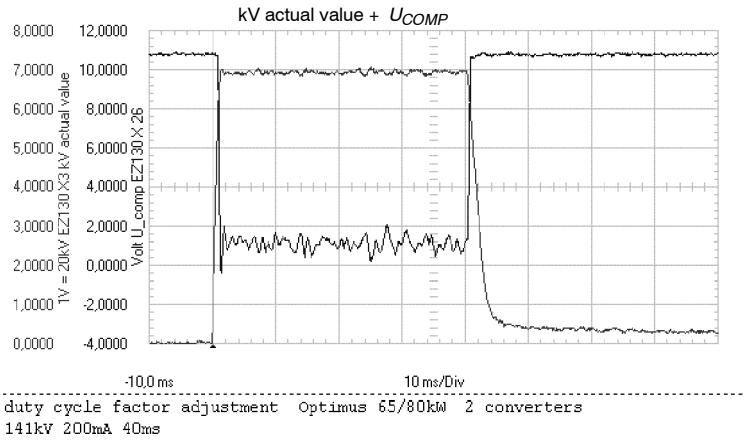


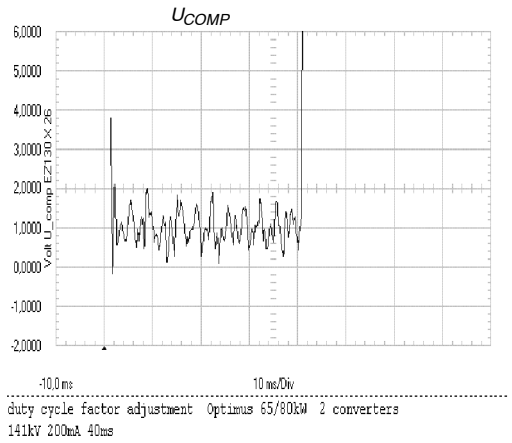
Figure 3 397H00

- If the U_{COMP} value does not match the requirements type in another Factor Duty Cycle value, <TRANSMIT> the screen and push the active RGDV button to get the new value validated.
- Switch an exposure.
  The values are measured in the stationary condition. The transient behavior at the beginning of the exposure is not taken into account.

Result: In standby the U_{COMP} value is at about +11V, during exposure the mean value U_{COMP} must be as given in table 1 or 2, refer to figure 4:



Oscillogram of a perfect alignment for 141kV



U_{COMP} for 141kV

Figure 4 401H00

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a) Standard setting 141kV

- Read the mean value of U_{COMP} for 141kV (see scope figure 4 or 5), correct the Factor Duty Cycle till U_{COMP} meets the required reference of +1V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of *AV HT*	Factor Duty Cycle:	Date:
141kV	100mA	PCB kV_control 3:	+1V	+1V / −0,5V	138kV		
141kV	200mA	PCB kV_control 4:	+1V	±0.5V	138kV		

Table 1: Factor Duty Cycle, settings 141kV (150kV limit)

Example how to correct the Factor Duty Cycle:

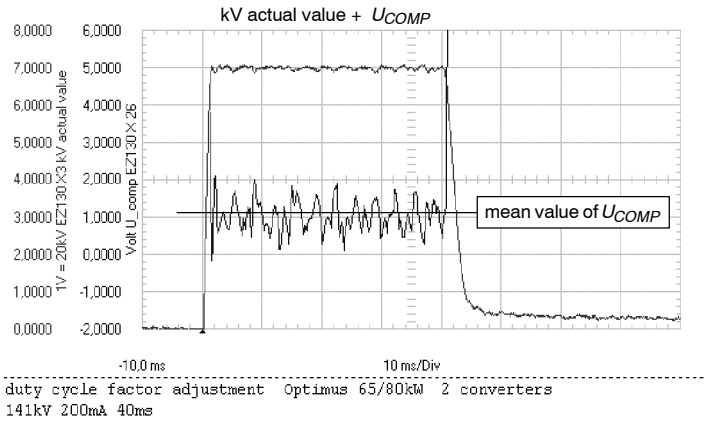
PCB kV_control 3:

- If the mean value of U_{COMP} is: > +2V **increase** the Factor Duty Cycle in steps of 0.01
  < +0.5V **decrease** the Factor Duty Cycle in steps of 0.01

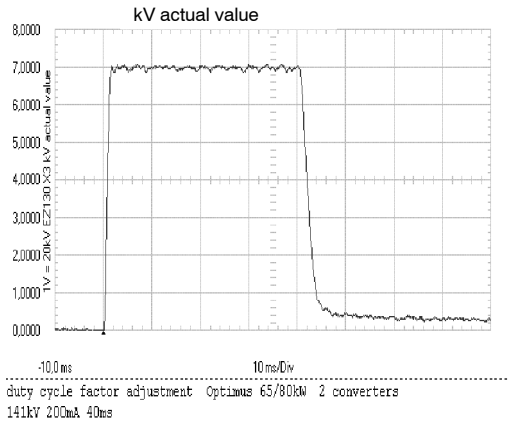
PCB kV_control 4:

- If the mean value of U_{COMP} is: > +1.5V **increase** the Factor Duty Cycle in steps of 0.01
  < +0.5V **decrease** the Factor Duty Cycle in steps of 0.01

- Check also the kV peak value *AV HT* (not the overshoot), it must be **138kV** for **141kV** setpoint. (see scope figure 5)
- Remove short link EZ130 X23 *GAIN_IN*.
- Record the findings in table1.



Optimus 80kW with 141kV, U_{COMP} = +1V



AV HT with overshoot

Figure 5 402H00

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b) Special setting 125kV
(In case there is no other tube connected that can withstand higher kV.)

- Read the mean value of U_{COMP} for 125kV (in principle figure 4 or 5).
- Correct the Factor Duty Cycle till U_{COMP} meets the required reference of 0V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of *AV HT*	Factor Duty Cycle:	Date:
125kV	100mA	PCB kV_control 3:	+0V	+1V / −0,5V	125kV		
125kV	200mA	PCB kV_control 4:	+0V	±0.5V	125kV		

Table 2: Factor Duty Cycle, 125kV limit

Example how to correct the Factor Duty Cycle:

PCB kV_control 3:

- If the mean value of U_{COMP} is: > +1V **increase** the Factor Duty Cycle in steps of 0.01
  < −0.5V **decrease** the Factor Duty Cycle in steps of 0.01

PCB kV_control 4:

- If the mean value of U_{COMP} is: > +0.5V **increase** the Factor Duty Cycle in steps of 0.01
  < −0.5V **decrease** the Factor Duty Cycle in steps of 0.01

- Check also the kV peak value *AV HT* (not the overshoot), it must be **125kV** for **125kV** setpoint.
- Remove short link EZ130 X23 *GAIN_IN*.
- Record the findings in table 2.

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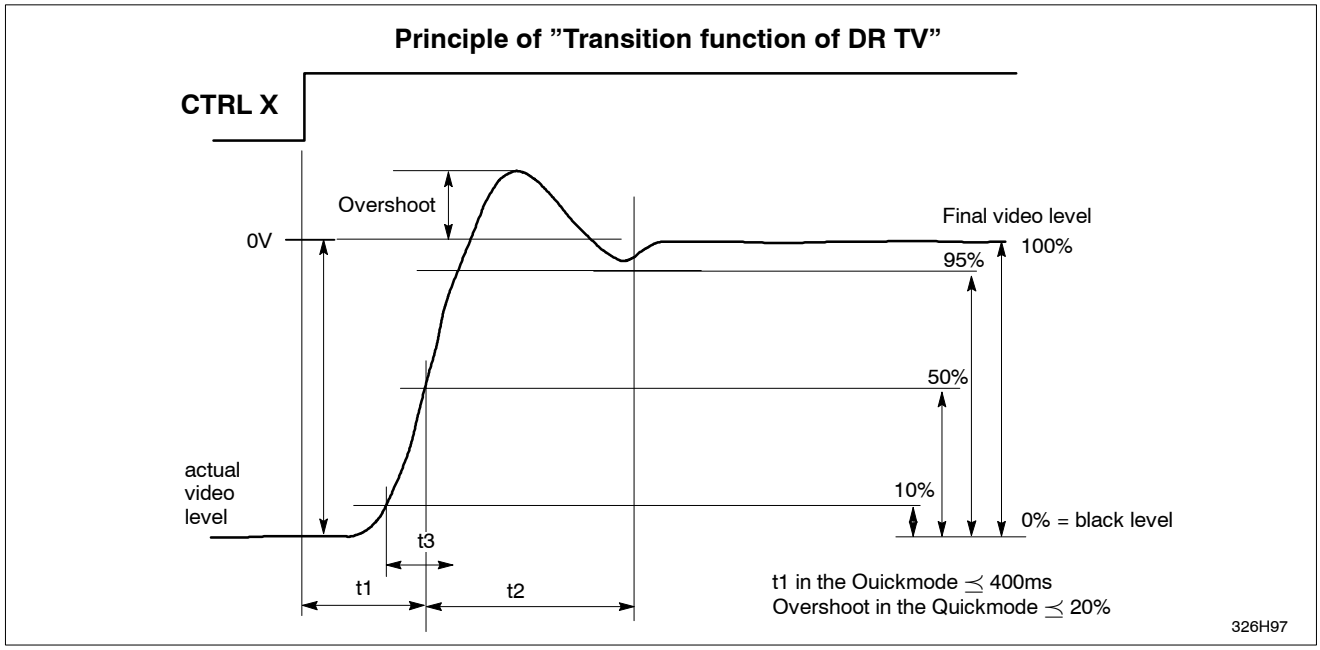
3. Dose rate alignment for continuous fluoroscopy when using the dose-rate signal DR TV (formerly ADC) // dose-rate control via TV-chain

3.1. Aim

The amplification factor of the control circuit must be adjusted such that
- the TV image becomes visible within about 400ms after fluoroscopy is switched on with RQXGFL
- there is no flashing of the TV image (overshoot < 20%).

Also see sketch below:



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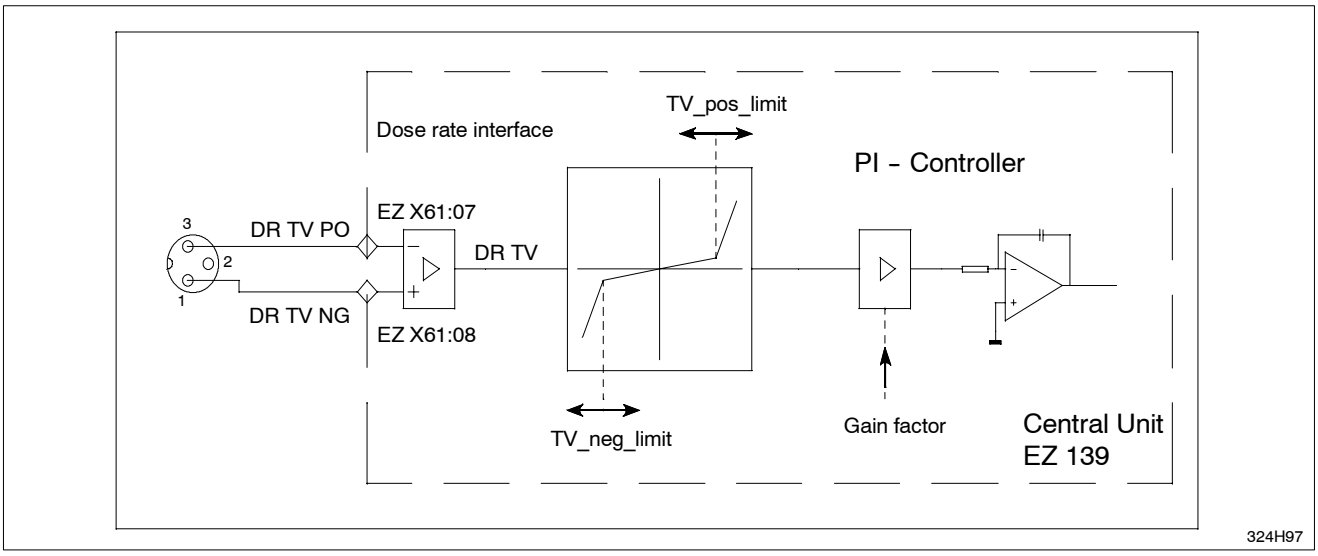
3.2. Principle

Adjusting value : Transition function of DR TV
Variables : TV_pos_limit / TV_neg_limit / Gain factor



- Set the gain factor to default value = 1.00 with FW XRGSCOPE:

  OPTIMUS
  --> Adjustments
  --> Dose rate control
  --> Amplification gain
  --> CONT **Gain factor 0.5...2 (default = 1): [1.000]**

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- With fluoroscopy **switched OFF**, measure the black level of the dose-rate signal of the TV chain.
  Suitable test points:
  - WN 25 DRDFP (with a TV chain XTV 11)
  - (EZ X61:7 = DR TV PO)

  The kink of the characteristic curve TV_pos_limit to be adjusted must be:
  TV_pos_limit = DR TV PO (black level measured) - 500mV
  Example: DR TV PO = 7.3V → adjusting value TV_pos_limit = 6.8V

- Set TV_pos_limit via XRGSCOPE:
  OPTIMUS
  --> Program
  --> Dose rate control
  --> **CONT:**

Program settings for continuous fluoroscopy:

```
+ ---------- CONT_MOD.TDL ---------- +
| scantime_TV [ms]:   [ 20.000] |       → 50Hz = 20ms
| scantime_TV valid:      Yes❑  |       → yes with control via TV chain.
|                               |         With photo diode = no.
| P_max_EDL [W]:       [  250]  |       → 250 default: Effective only when SID
|                               |         WB X12:1 DRLM is switched ON.
| TV_pos_limit [V]:     [6.8]   |       → DR TV PO - 500mV.
|                               |         (TV black voltage - about 500mV)
| TV_neg_limit [V]:     [-6.8]  |       → = - TV_pos_limit [V]
| ------------------------------- |
|   < OK >                      |
| ------------------------------- |
```

In case the switch ON procedure is fast enough with this setting
T1 ≦ 400ms in quick mode or T1 ≦ 500ms in normal mode
and the TV chain does not flash when fluoroscopy is switched ON,
overshoot ≦ 20%
the alignment with the oscilloscope described below is **not** required.

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3.3. Alignment of DR TV with the oscilloscope

Settings of the oscilloscope:

Y1	to EZ 150 X6	:	EN X C/	[10V/div]
Y2	e.g. with XTV11 to WN 25	:	DRDFP	[5V/div]
Ground	to EZ 150 X5	:	GNDA	
Time base		:	200ms/div	
Trigger		:	Y1 / - DC	

The alignment should not be carried out in the quick mode since the differences of the transition functions are not big enough in the quick mode. However, in the normal mode the overshoot is slightly higher than 20%.

Since fluoroscopy is automatically in the quick mode for up to 30s after the end of fluoroscopy, after each oscillogram fluoroscopy must be switched OFF for at least 30s:

Pause > 30s → Fluoro ON → Oscillogram → Fluoro OFF
→ Pause > 30s → Fluoro ON → Oscillogram → Fluoro OFF

Fluoroscopy adjustments for all oscillograms:

- Dark voltage of the TV chain measured: DR TV PO $_{dark}$ = 7.3V

XRGSCOPE:

OPTIMUS
--> Program
--> Dose rate control
--> **CONT:**

```
scantime_TV [ms]      : 20.000  (→ 50Hz)
scantime_TV valid     : Yes
P_max_EDL [W]         : 250
```

Operating point of fluoroscopy in the automatic mode (example XTV 11):

- 9" I.I. format
- Filter in the path of radiation: 1.5mmCu + 20mmAl ==> 74kV/ 2.2mA.

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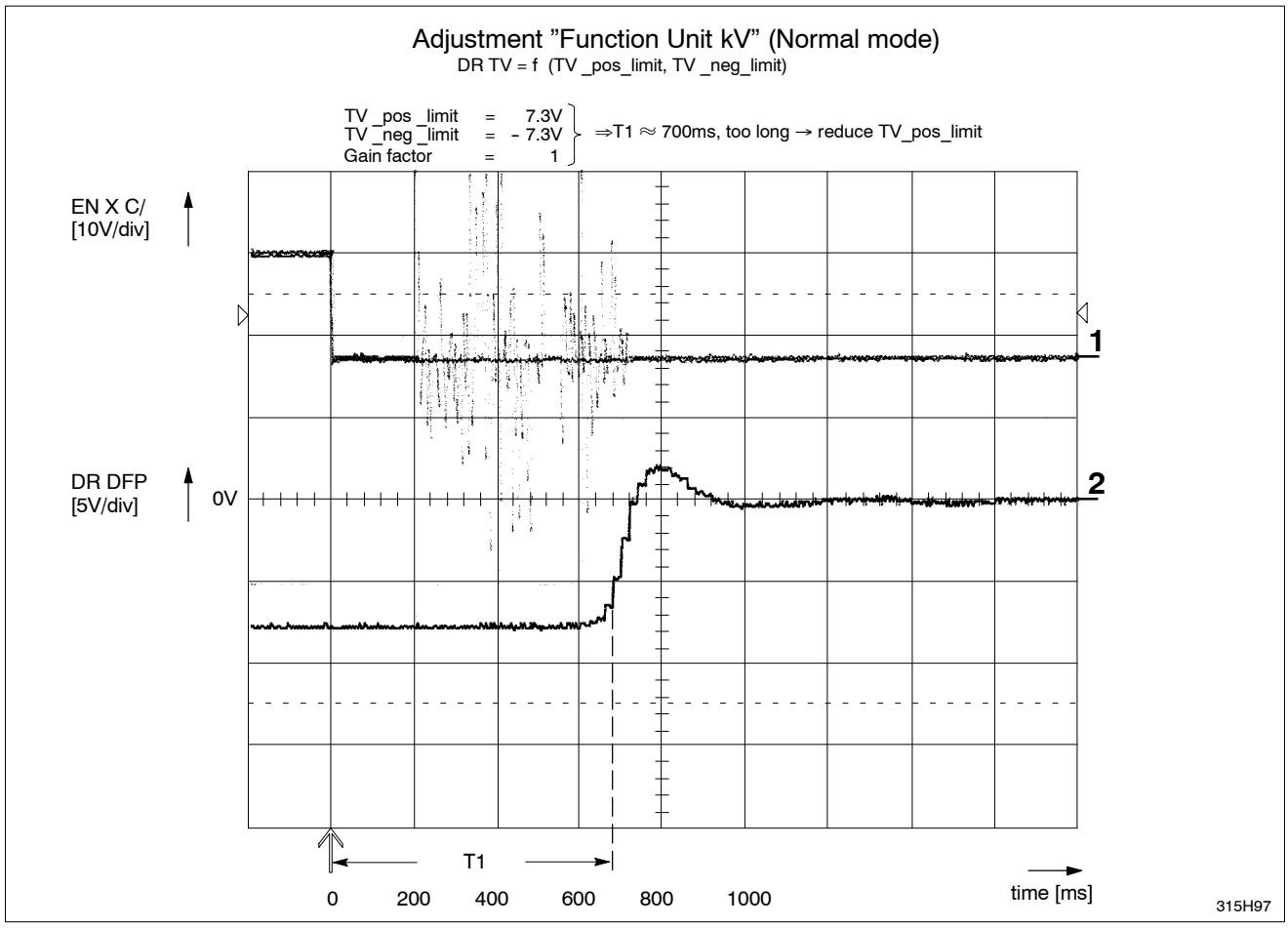
First reference oscillogram:

Values adjusted with XRGSCOPE:

- `TV_pos_limit [V]  : [ 7.3 ]`
- `TV_neg_limit [V]  : [-7.3 ]`
- `Gain factor       : [ 1.00]`

} ==> T1 ≈ 700ms --> too long --> `reduce TV_pos_limit [V]`



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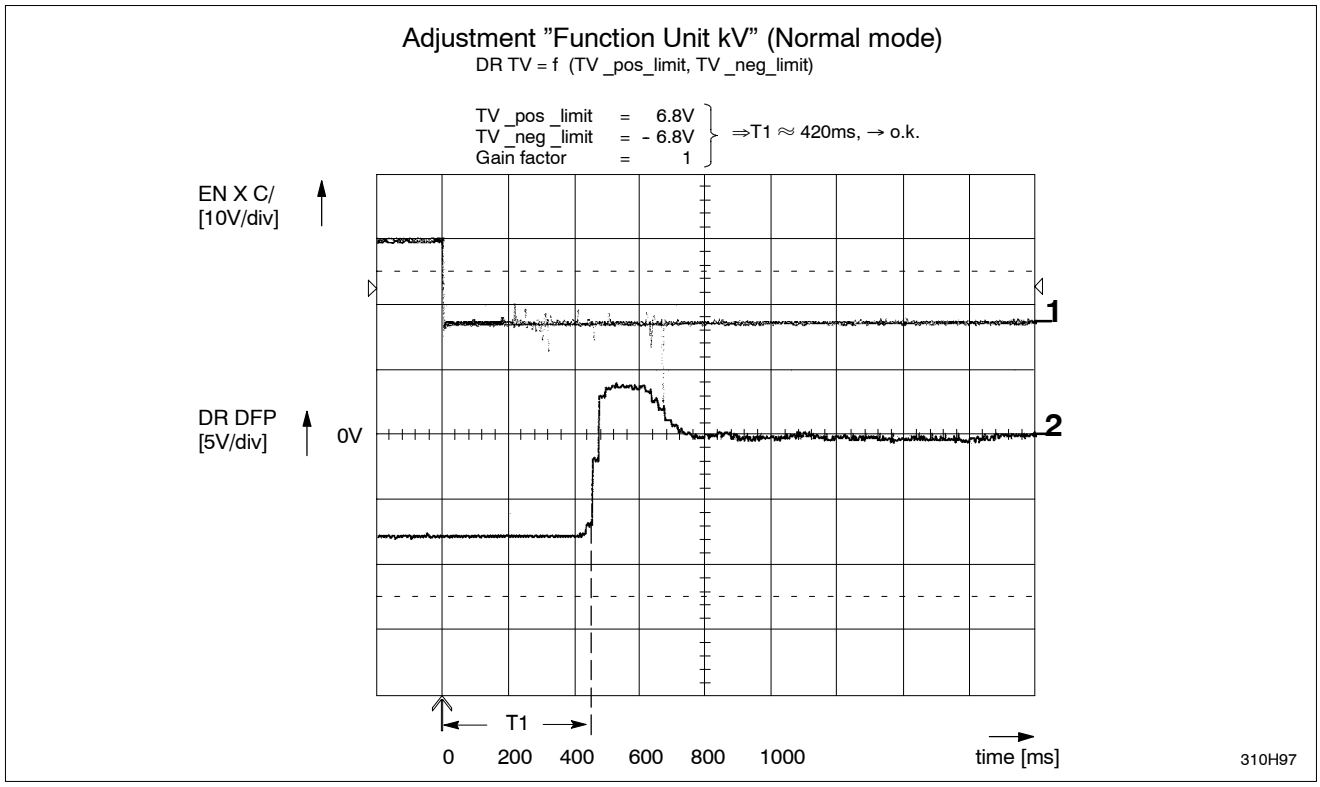
Second reference oscillogram:

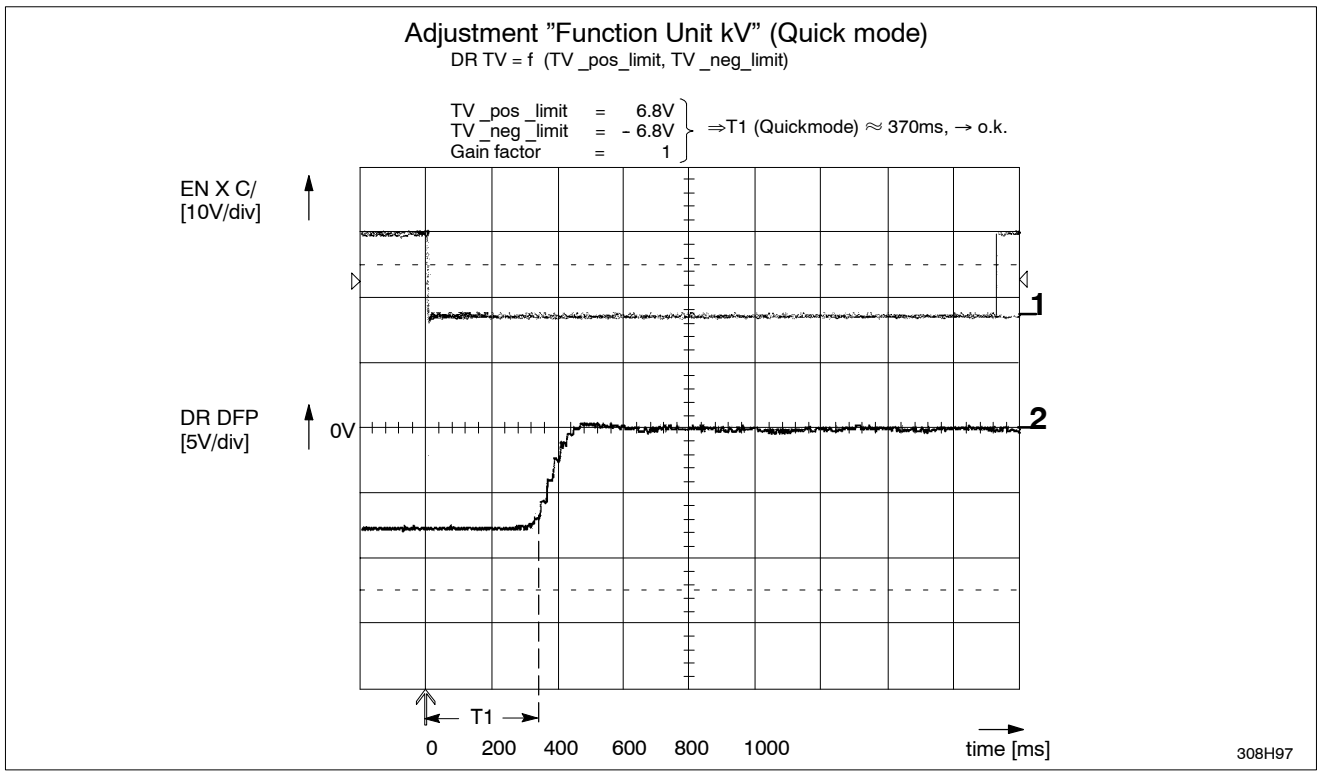
Values adjusted with XRGSCOPE:

- TV_pos_limit [V] : [6.8]
- TV_neg_limit [V] : [-6.8]
- Gain factor : [1.00]

==> T1 ≈ 420ms --> o.k.

and gain factor can remain as they are





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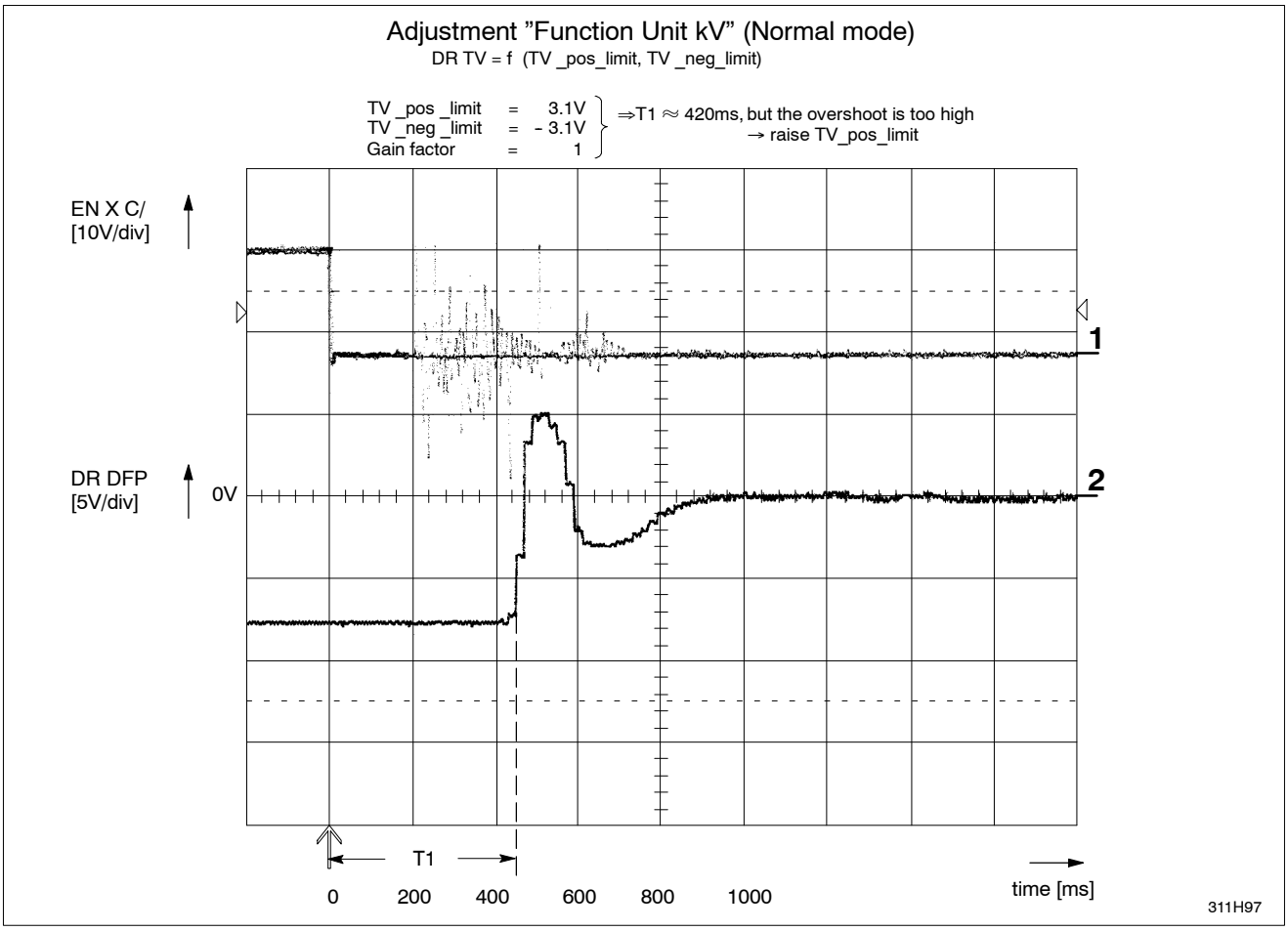
Third reference oscillogram:

Values adjusted with XRGSCOPE:

- `TV_pos_limit [V] : [ 3.1 ]`
- `TV_neg_limit [V] : [-3.1 ]`
- `Gain factor : [ 1.00]`

==> T1 ≈ 420ms --> o.k., but the overshoot is too high
The TV image flashes!
--> Raise TV_pos_limit [V]



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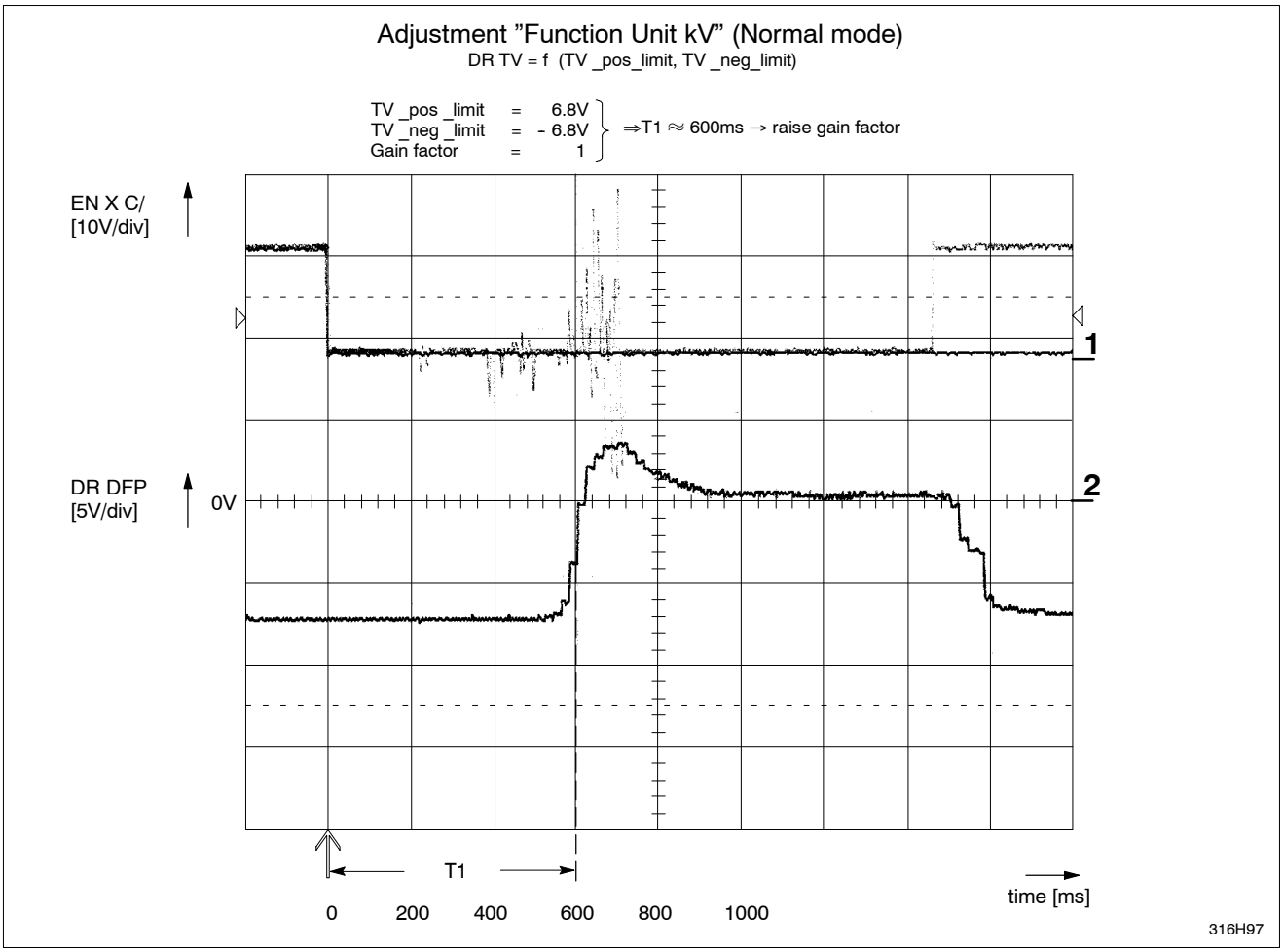
Forth reference oscillogram:

Values adjusted with XRGSCOPE:

- TV_pos_limit [V] : [6.8]
- TV_neg_limit [V] : [-6.8]
- Gain factor : [0.50]

==> T1 ≈ 600ms --> too long --> Raise gain factor to 1.00!



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4. Maximum patient entrance dose rate: Entrance Dose rate Limiter (EDL)

4.1. Aim

In some countries the maximum patient entrance dose rate must be limited to comply with the respective national regulations, for instance 10R/min = 1.4567μGy/s in the USA.

4.2. Principle

The maximum patient entrance dose is measured with maximum kV. By reducing the maximum power P_max_EDL provided by the generator, the dose rate is reduced until it complies with the national regulations or the individual wish of the user.

Note
*The dose rate reduction programmed via P_max_EDL is effective only when the SID contact (**S**ource **I**mage **D**istance) is switched ON: WB X12:1 DRLM → closed!*

4.3. Alignment

- Cover the I.I. with lead such that with fluoroscopy maximum kV (110kV) are adjusted (protection of the I.I. against excessive radiation).
- Adjust the exam./aux. unit in such a way that the SID contact is closed.
  If necessary, place a shorting plug on decade: WB X12:1 <----> X12:10 (ground).
- Adjust the exam./aux. unit in such a way that the smallest distance between tube and patient is effective.
- Position the dose rate measuring chamber in such a way that it is at the same height where the radiation would enter the patient.
- Switch ON fluoroscopy.
- Reduce/raise **P_max_EDL [W]** with the service software XRGSCOPE until the dose rate is identical with the maximum permissible value:

XRGSCOPE OPTIMUS
--> Program
--> Dose rate control
--> **CONT:**

```
+ ---------- CONT_MOD.TDL ---------- +
| scantime_TV [ms]:   [ 20.000]      |
| scantime_TV valid:      Yes        |
|                                    |
| P_max_EDL [W]:       [ nnn]        |
|                                    |
| TV_pos_limit [V]:     [6.8]        |
|                                    |
| TV_neg_limit [V]:     [-6.8]       |
| ---------------------------------- |
|   < OK >                           |
| ---------------------------------- |
```

Range: 0 ... 9000W (250 default)
→ Effective only when SID contact WB X12:1 DRLM is switched ON.

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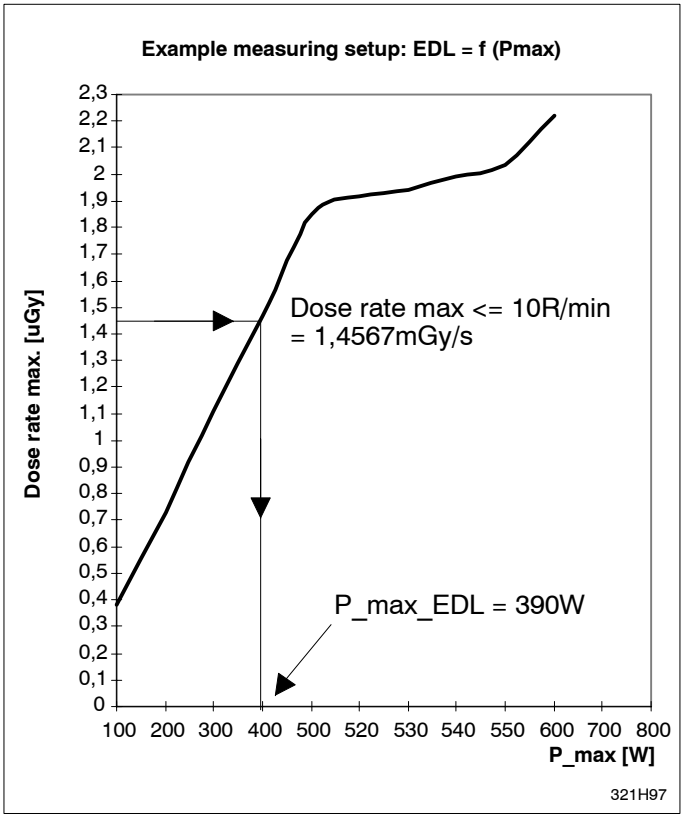
- Note the measuring values:

P_max_EDL: [W]														
Dose rate: [µGy/s]														

Example of a measuring setup:



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